TREND CURVES OF THE RATE OF SPECIES DESCRIPTION FOR CERTAIN NORTH AMERICAN COLEOPTERA

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Abstract

Trend curves of the rate of species description are presented for some families of Coleoptera, and a resumé curve is given for 36% of the North American beetles described to 1970. There is a discussion of the characteristics of trend curves and the methods used in this paper. For each trend curve the years for approximate end-point of species description are given with an estimate of the final total number of species. The resume curve allows an estimate of the final total number of described species for North America (27,400).

Introduction

An estimate of the final total number of living species for a group in which species tabulation is unfinished has very often been little more than an educated guess. Though these estimates are of great general interest, there is the uncertainty of accepting nonconfirmable figures arrived at by unknown methods. Fortunately, there is now a means of estimating final species totals that promises reliability and which allows the results to be verified. This means is the trend curve technique developed by Steyskal (1965) for the rate of species description. This very useful statistical tool affords a relatively precise means of estimating final species totals.

Trend Curve Characters

A trend curve plotted for the rate of species description for a group well-known taxonomically (for example, birds or butterflies of North America) is a smooth sigmoid curve, as shown in Steyskal (1965:880). In rate of climb this curve starts slowly, gradually increases until there is a nearly straight-line ascent, then slows, with the curve arching over, and finally leveling off. Such a curve in which the upper end has leveled off and nearly or quite ceased to climb shows that the finite number of species in nature is essentially known, and the end-point of species description is attained or very near.

In a trend curve there is a very strong tendency for the top half of the curve to match closely the bottom half. Thus a curve of an incompletely known group bears a predictive value that can be used to estimate the final species total. To make use of this predictive value, the curve must be well past the mid-point with the rate of ascent clearly having slowed so the end-point can be plotted. By transposing the bottom of this curve over the top,

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one can arrive at a prediction of the species total for the group. When a partial curve is still on the ascent with the rate of climb not yet having slowed, there is no way of accurately plotting the end-point of the curve.

Methods and Application

In plotting a trend curve of the rate of species description, use graph paper and fix the years by decades along the bottom of the graph (x-axis),

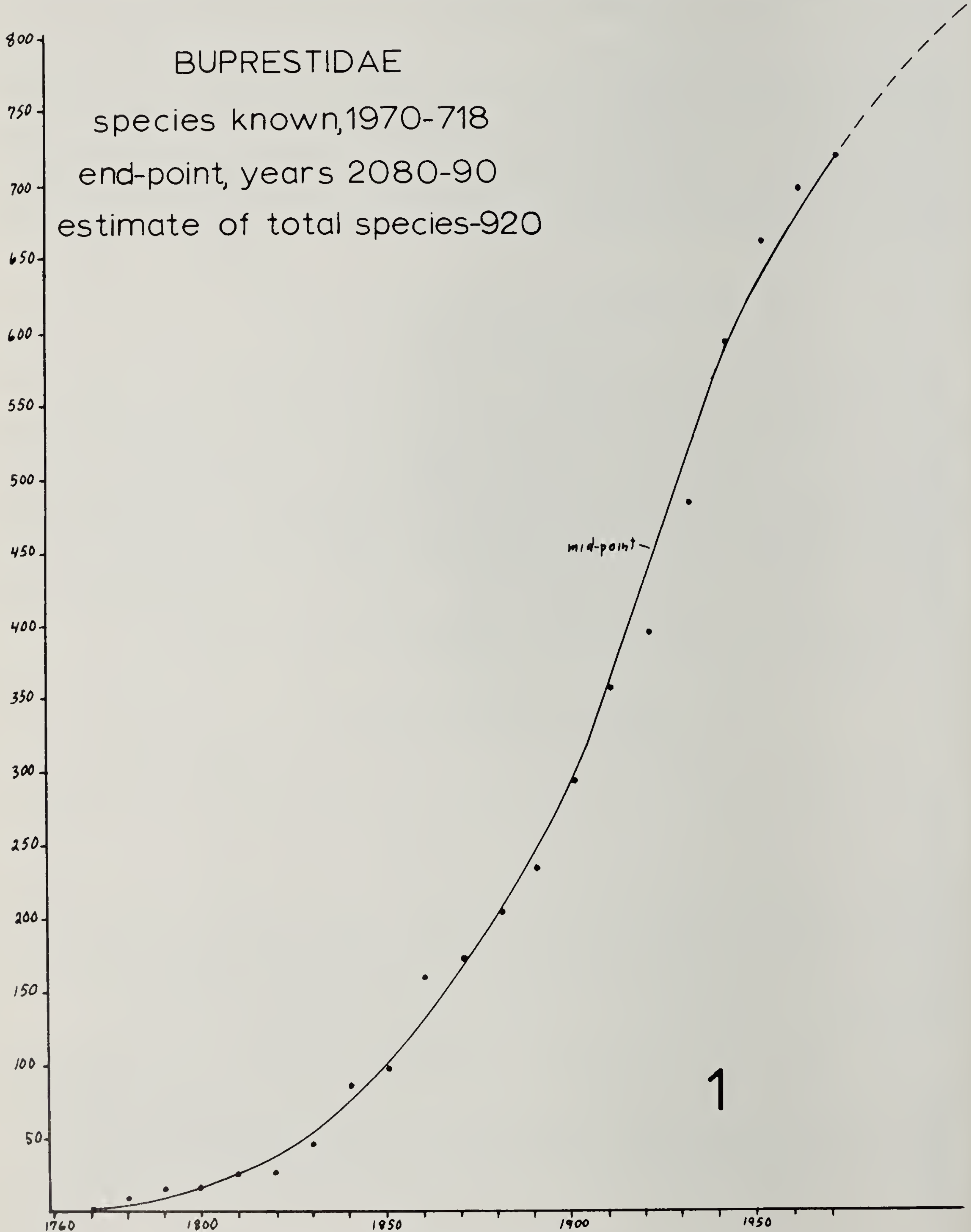
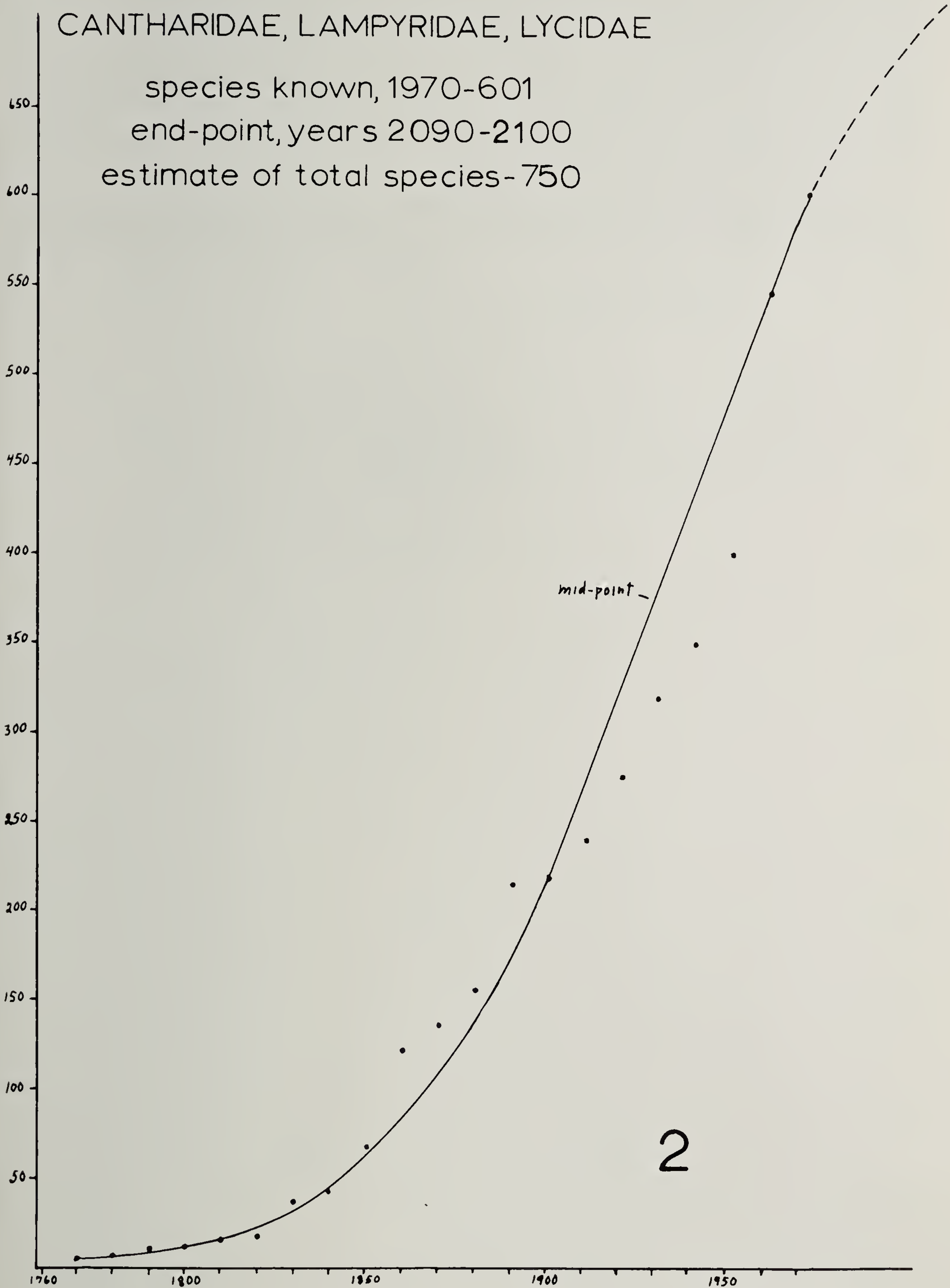


Fig. 1-12. Trend curves for indicated families. Fig. 13. Resumé trend curve.

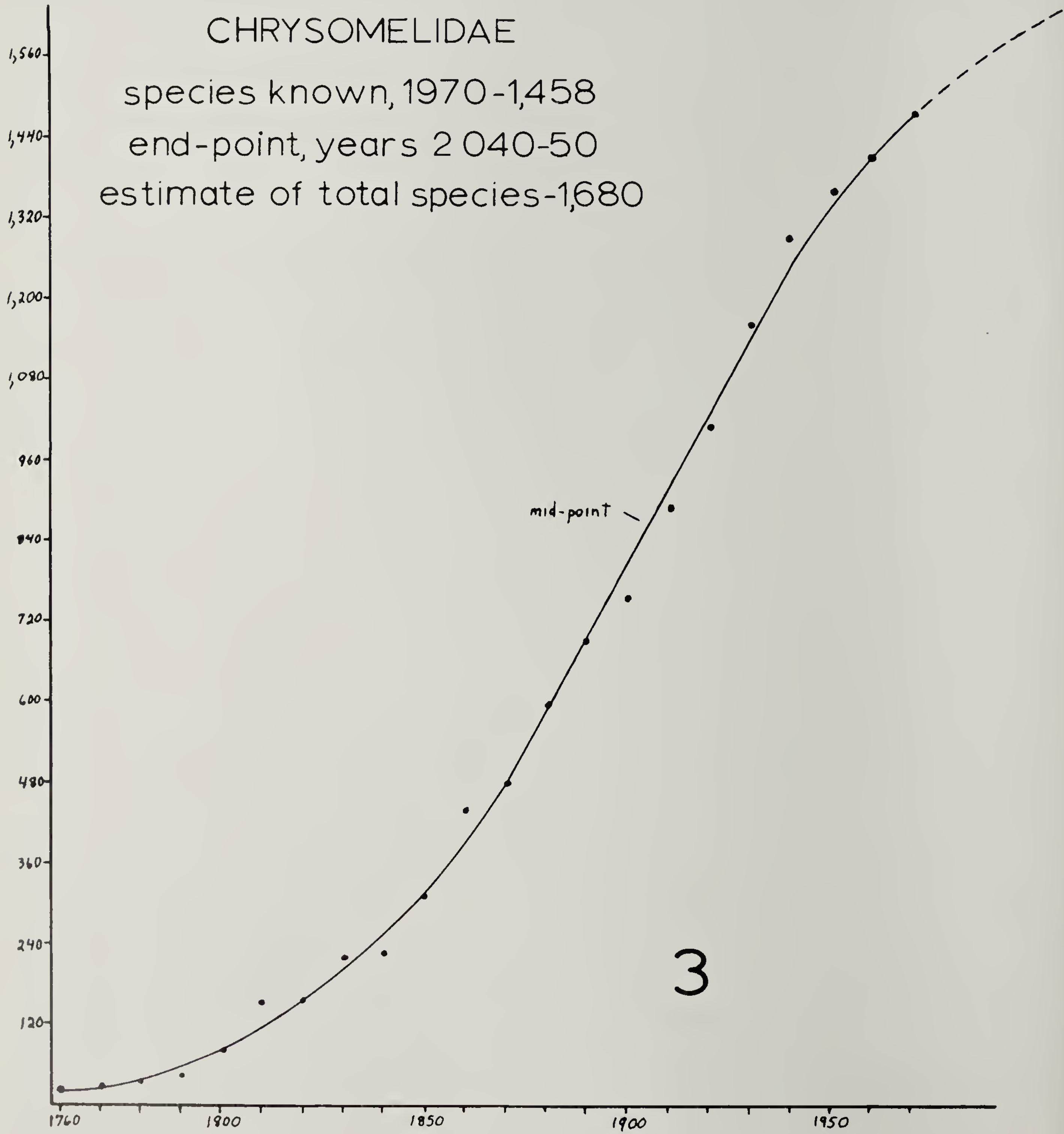
and the numbers of described species along the left, vertical side of the graph (y-axis). Place points on the graph for the accumulated number of presently valid species at the end of each 10-year period. Placement of the points on the graph must be done with great care, especially around the upper end of the graph. The latter area is critical because misplacement of a point in this area can easily distort a curve and produce unreliable re-



sults. To draw the curve connect the first point to the last while joining the maximum number of points and leaving an equal or nearly equal number of points on each side of the curve. A French curve is useful for drawing a smooth curve.

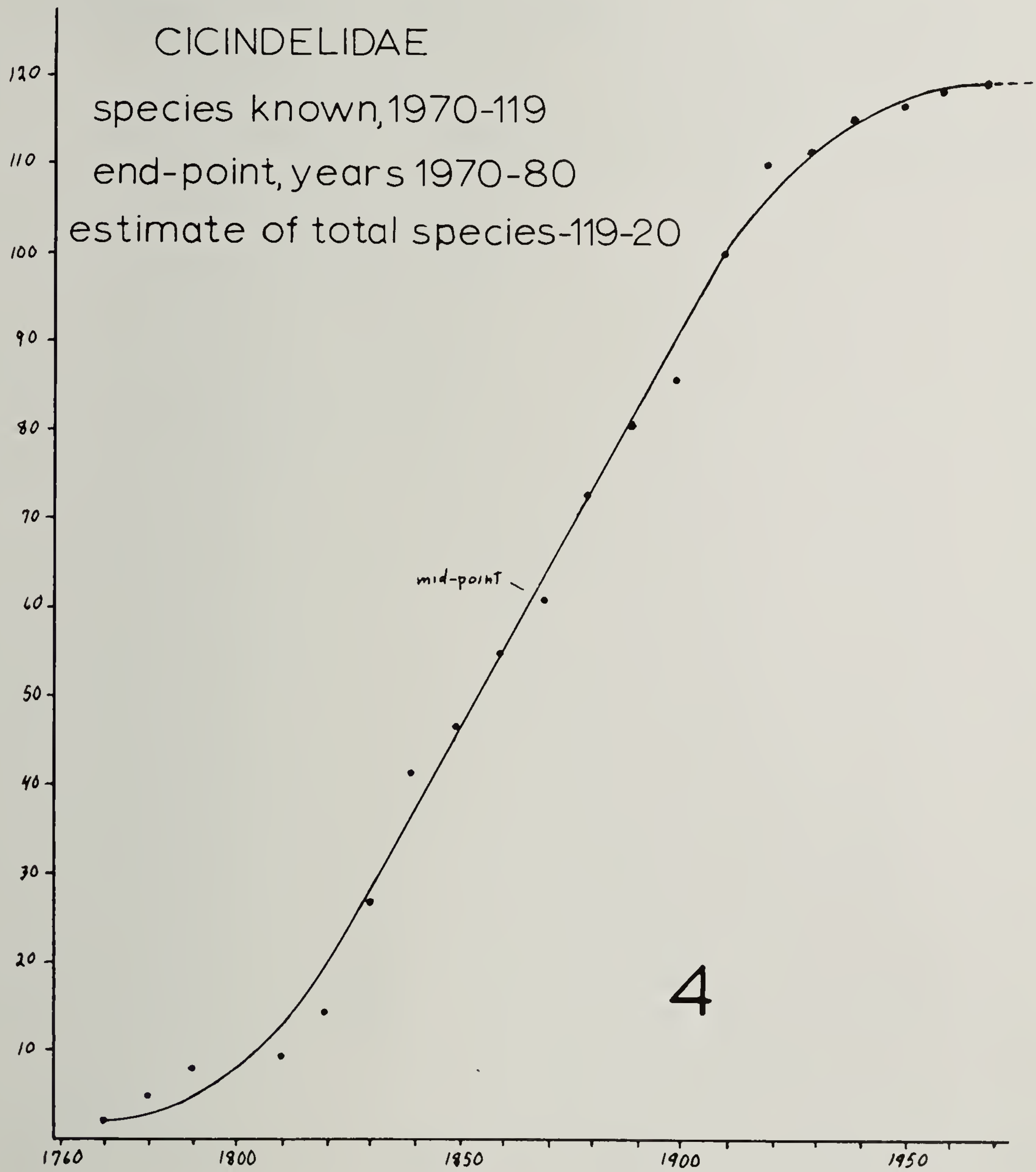
From the starting point for our knowledge of species numbers (1758) the acceleration of a curve is gradual with the chief limiting factors being the small number of working taxonomists and the small size of collections. Increase in the number of taxonomists, the size and number of collections, and improvement of techniques result in acceleration of the rate of climb, with finally, a nearly straight-line ascent. As the final total number of species in nature is approached, the rate of climb slows, and with description of the last few species of very small populations, cryptic habits, or those very difficult to discriminate, the curve levels off to remain level once species descriptive work is finished.

An obvious basic requirement essential to assure accuracy in use of this technique is that the described species be valid. If wholesale, undetected



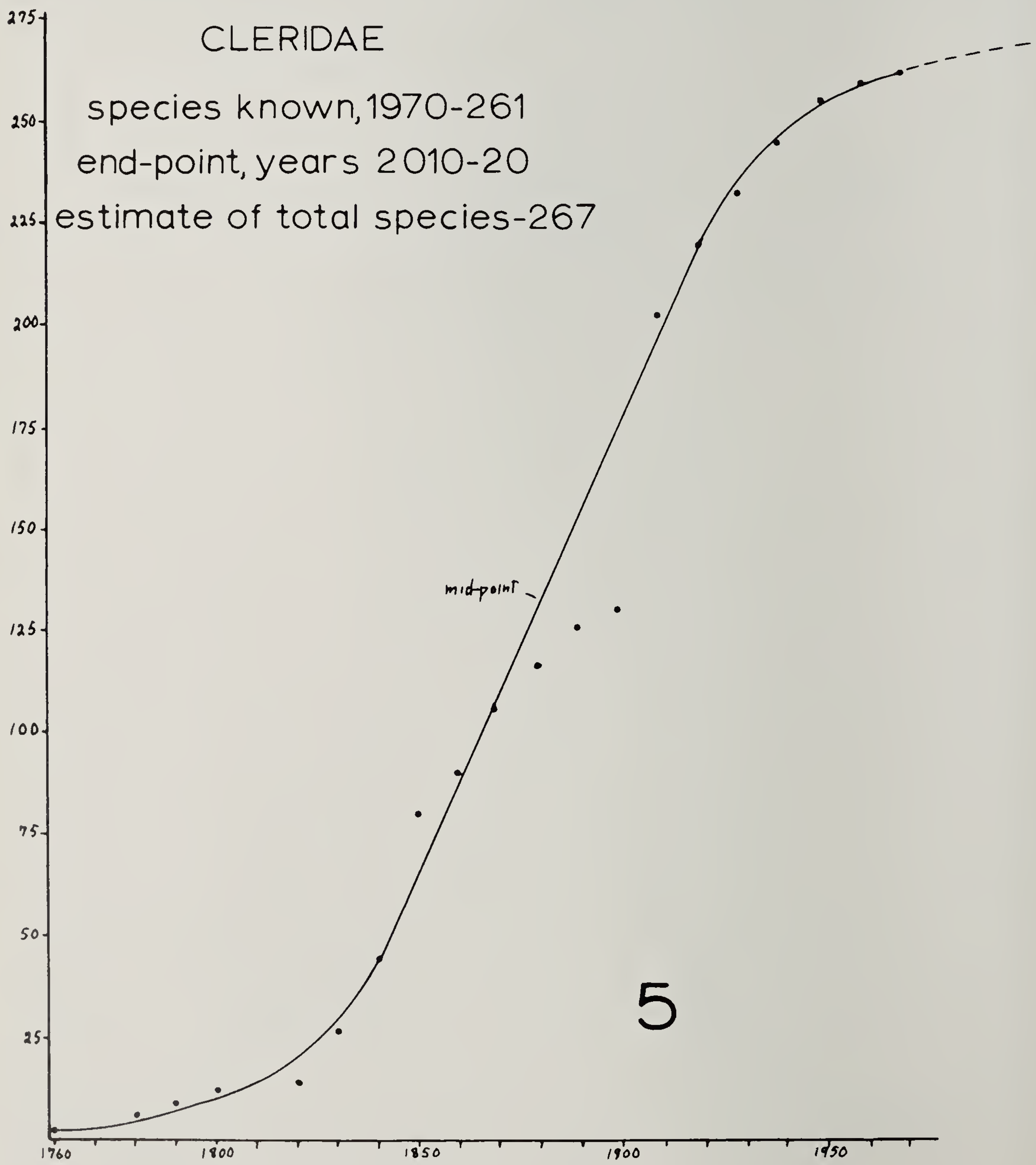
synonymy exists, once this synonymy is discovered, the estimate of final species total will be found to be meaningless, because the numbers used in plotting the curve were excessively high. A trend curve of a family in which appreciable undetected synonymy exists would thus give a final estimate of species in excess of a reasonably accurate number. Because of these facts, I have avoided the families in which Thomas L. Casey described numerous species, because re-examination of his work has frequently resulted in a large percentage of his species being synonymized. Some of the groups in which he labored have been re-examined since his time, but many have not been. My avoidance of the families in which Casey worked leaves 4 of the 7 largest families of beetles in North America (Carabidae, Staphylinidae, Curculionidae, and Tenebrionidae) out of this study. Though, in compiling these trend curves, I have avoided the families in which Casey worked extensively, the results of his work still introduce a possible source of error in some conclusions reached as discussed below under results.

Application of the trend curve technique to a relatively small family is not as likely to produce significant results as is application to a large family. The rate of species description for a small or obscure family is too



readily affected by irregular taxonomic progress. This very irregular progress in such a family makes it difficult or impossible to plot a meaningful curve. As a general guideline about 200 species should be the optimum minimum size of a group to insure production of significant results. Between 150 and 200 species may provide good results, between 100 and 150 species are generally not sufficient, and less than 100 species will rarely suffice. The difficulty in trying to establish more precise guidelines than the above rather hazy ones can be shown by the Cicindelidae (Fig. 4), a family of 119 species that gives a smooth and apparently reliable curve. Almost certainly the popularity of the Cicindelidae with collectors and taxonomists accounts largely for the steady rate of progress in species description and good curve results.

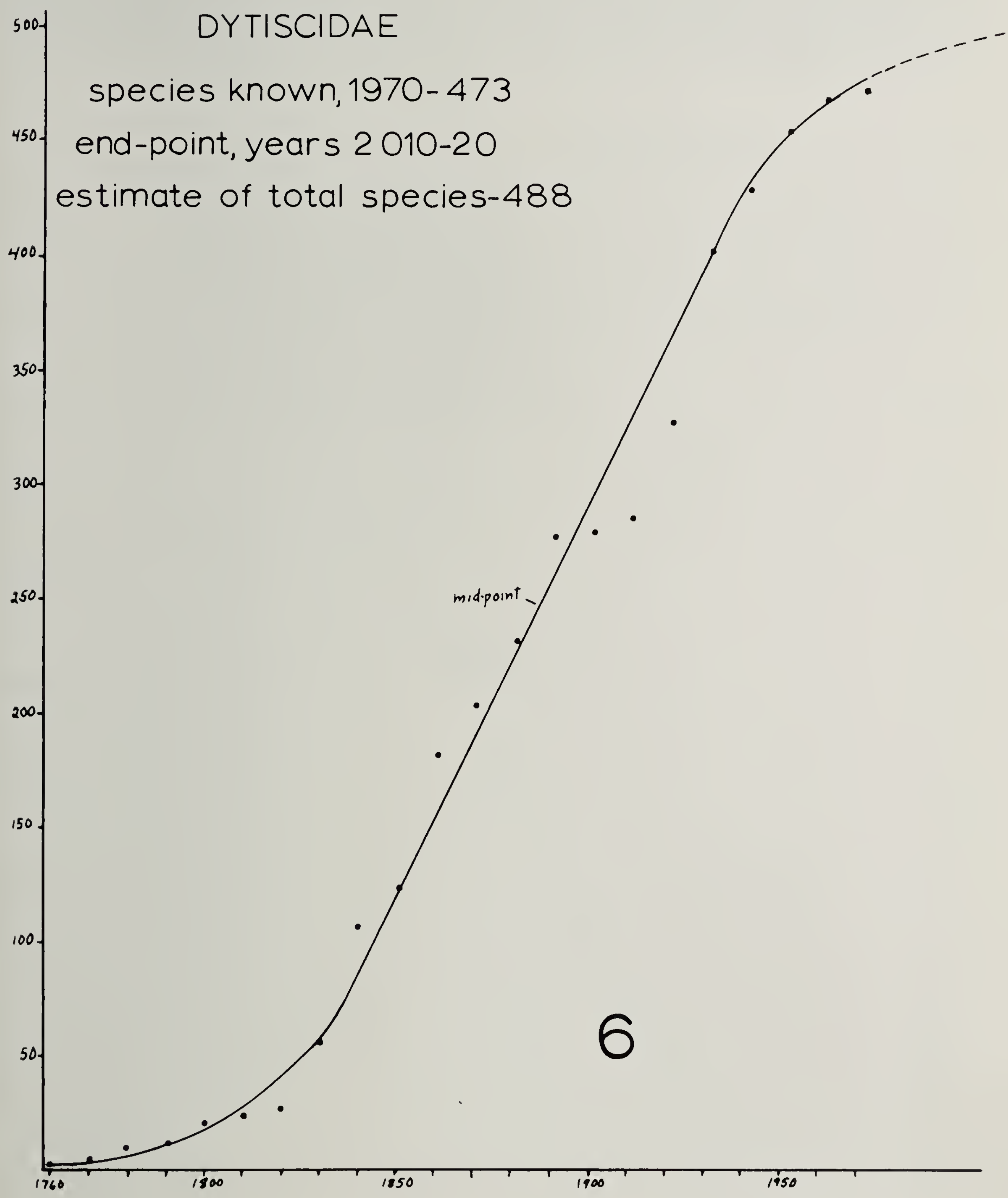
In compiling numbers of species for the curves, I relied on the Leng catalog and its supplements to 1948, and from there to 1970 I used the Zoologi-



cal Record. In the supplements and the Zoological Record where revalidation of former synonyms about equaled the new synonymy, I did not alter my figures in accordance with these changes. When new synonymy clearly out-numbered revalidations, I changed my figures accordingly. An up-to-date catalog is a tremendous aid for work of this sort. When one is available for the Coleoptera it will enable close checking of the results herein and with much less effort than I have expended.

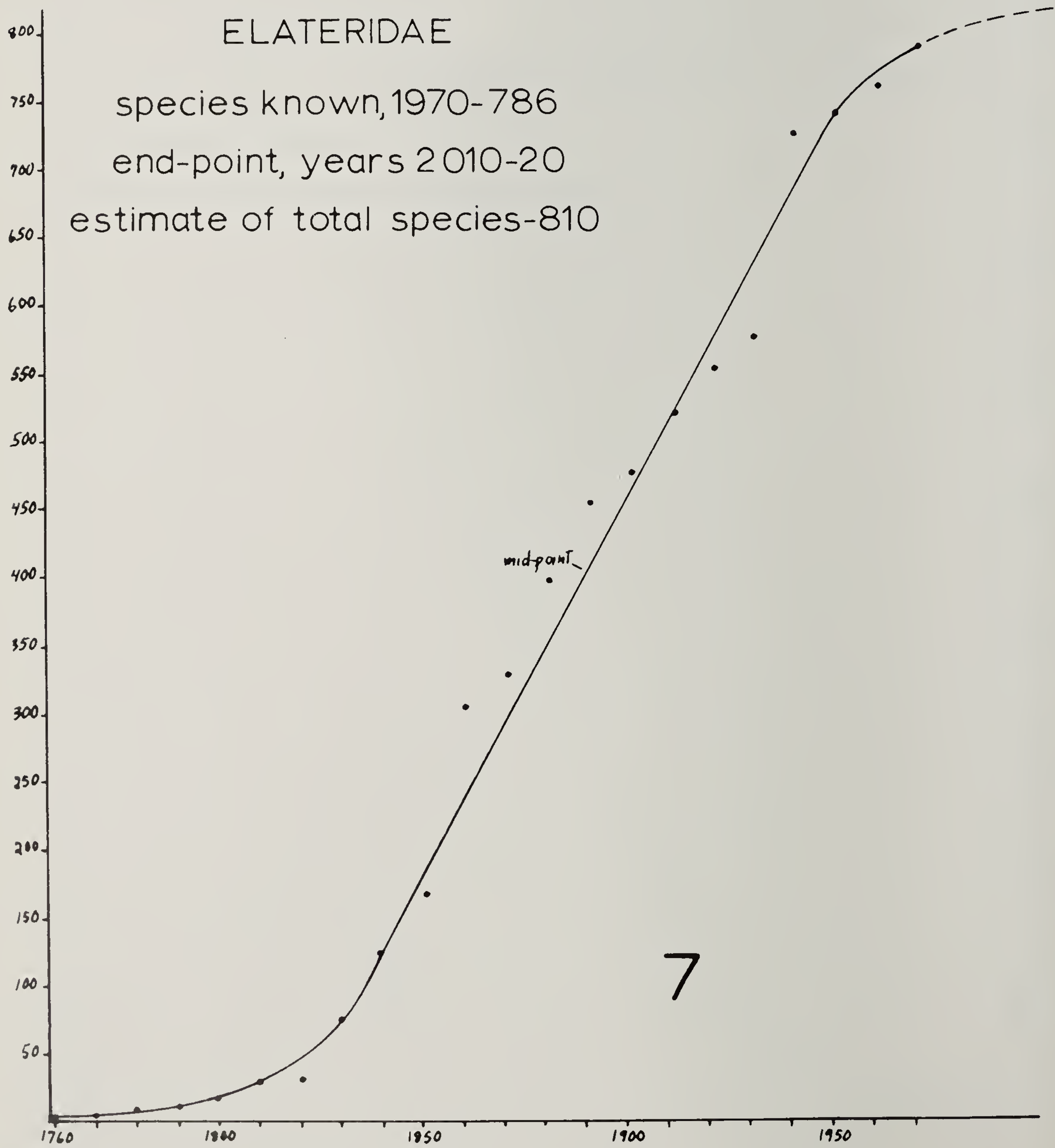
Results

A large beetle family that is reasonably popular with taxonomists and/or economically important often gives a very good agreement of



points with a sigmoid curve, as shown on the graph for the Chrysomelidae, Fig. 3. With about 1458 species as of 1970 this is one of the 4 or 5 largest families of beetles in North America. Small or even moderate-sized families that are not highly attractive to taxonomists are often subject to irregular progress in species description, and thus may show less than good agreement of points with a sigmoid curve, as for Melyridae (Fig. 10), Hydrophilidae (Fig. 8), and Meloidae (Fig. 9).

A small beetle family that is quite popular with collectors and taxonomists can show a good agreement of points with a sigmoid curve, and provide a curve of apparent high reliability; an example (mentioned previously) is the Cicindelidae, Fig. 4. The 119 species as of 1970 could be all, or nearly all that will be described, hence my estimate of 119-120. Of those families for which I have prepared trend curves, the Cleridae (Fig. 5) follow the Cicindelidae in being nearest the end-point. The curve for the Cleridae is notable for the very close agreement of the last 7 points with the curve



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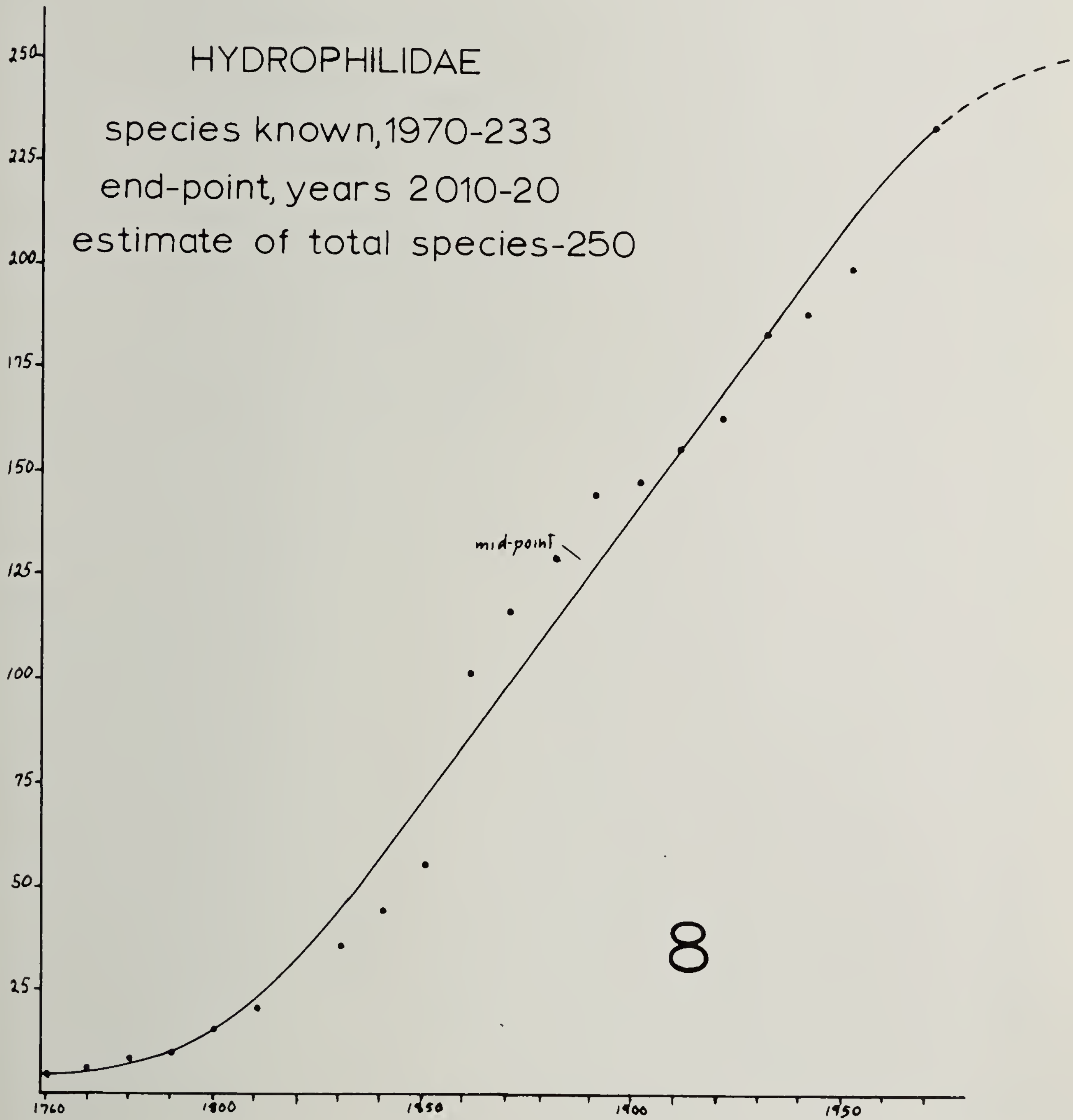
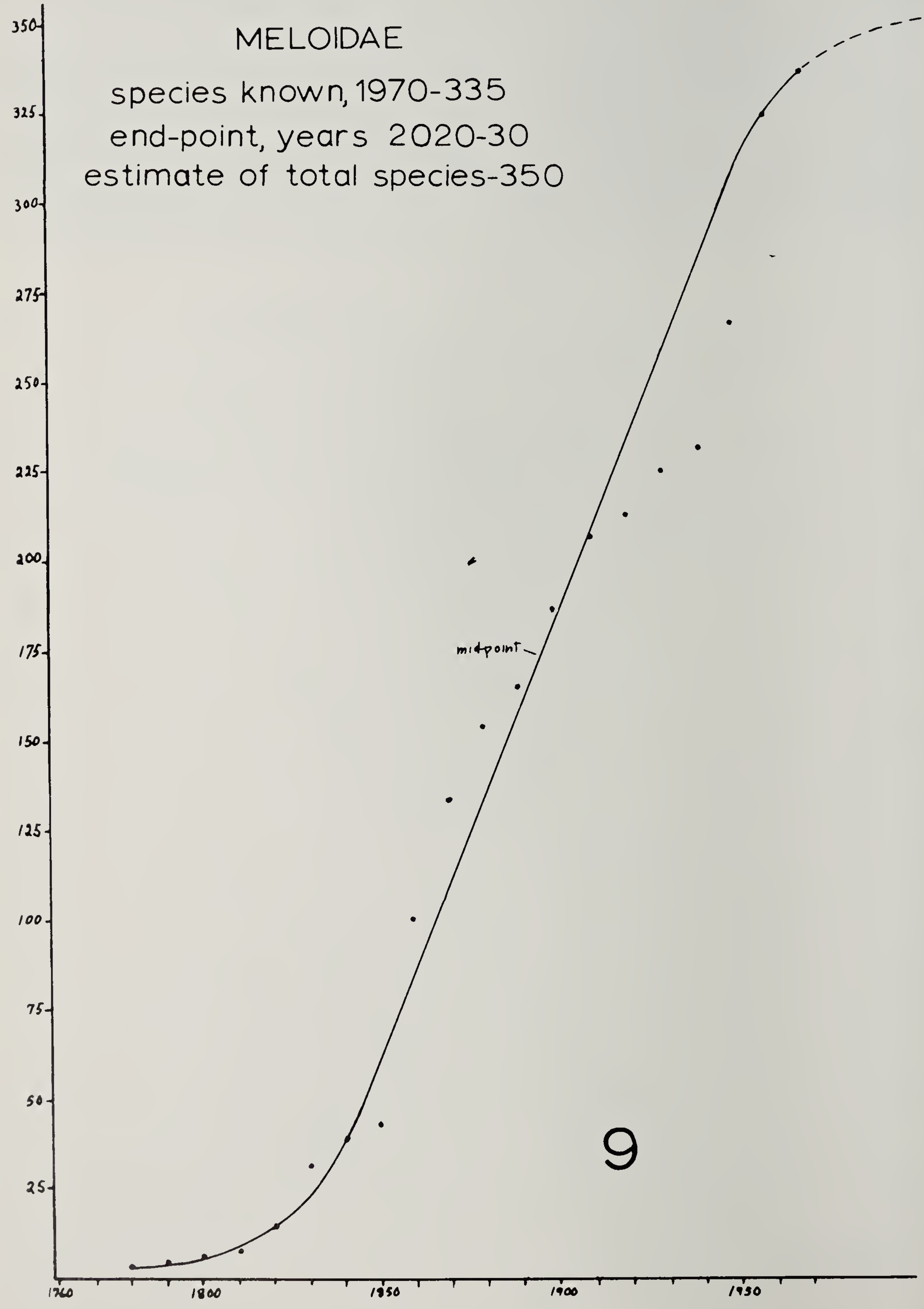
I have drawn. Similarly, the curve for the Scolytidae (Fig. 12) gives good agreement of the last 5 points with the curve.

An example of the effect that improvement of technique can have on the rate of species description is shown by Fig. 2 that jointly includes Cantharidae, Lampyridae, and Lycidae. On this graph note the great increase in species number from 1950 to 1960; this was largely due to use of male genitalia in distinguishing species. Had this curve been drawn with only the data available to 1950, it clearly would have given a far different result than that which it gives here.

The results for the families Buprestidae (Fig. 1) and Scarabaeidae (Fig. 11) deserve discussion. As theory requires, I have transposed the bottom half of each curve over the top half to arrive at predictions for each graph. However, if one ignores the curves I have drawn and examines the last 4 points on each graph, in each case these points appear to inscribe a curve that is abruptly slowing in rate of climb, and which departs greatly from the form of the curve inscribed by the points at the bottom of each graph. Both of

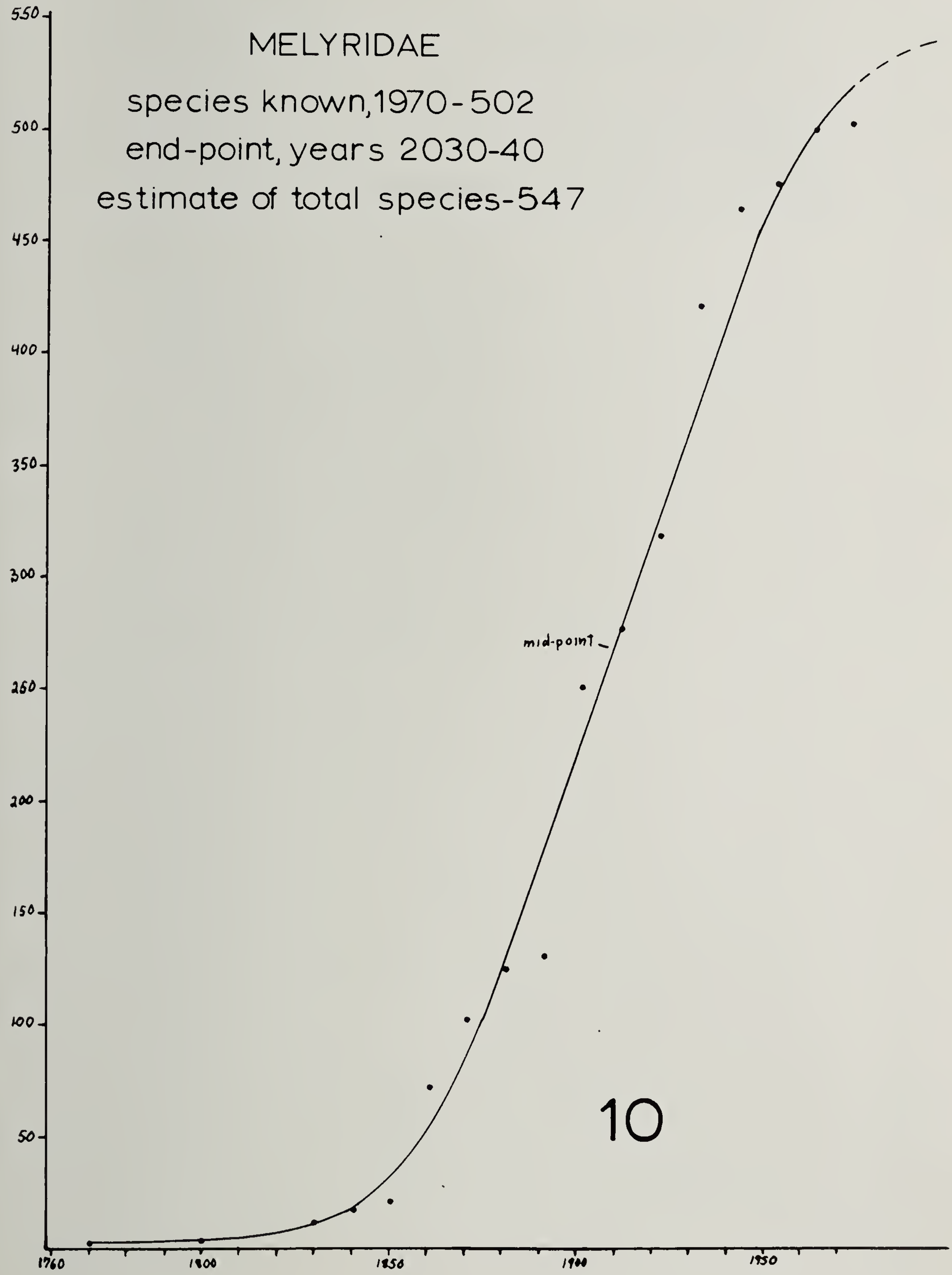


these families are popular with collectors and taxonomists, and the possibility arises that due to this popularity taxonomists are describing the remaining species at a greater rate than would normally be expected and thus causing each curve to deviate from its anticipated form. As a test, I have followed the more abrupt curvature of the last 4 points for each of my graphs, and for the Buprestidae this has led to a final species total of 785 (as con-

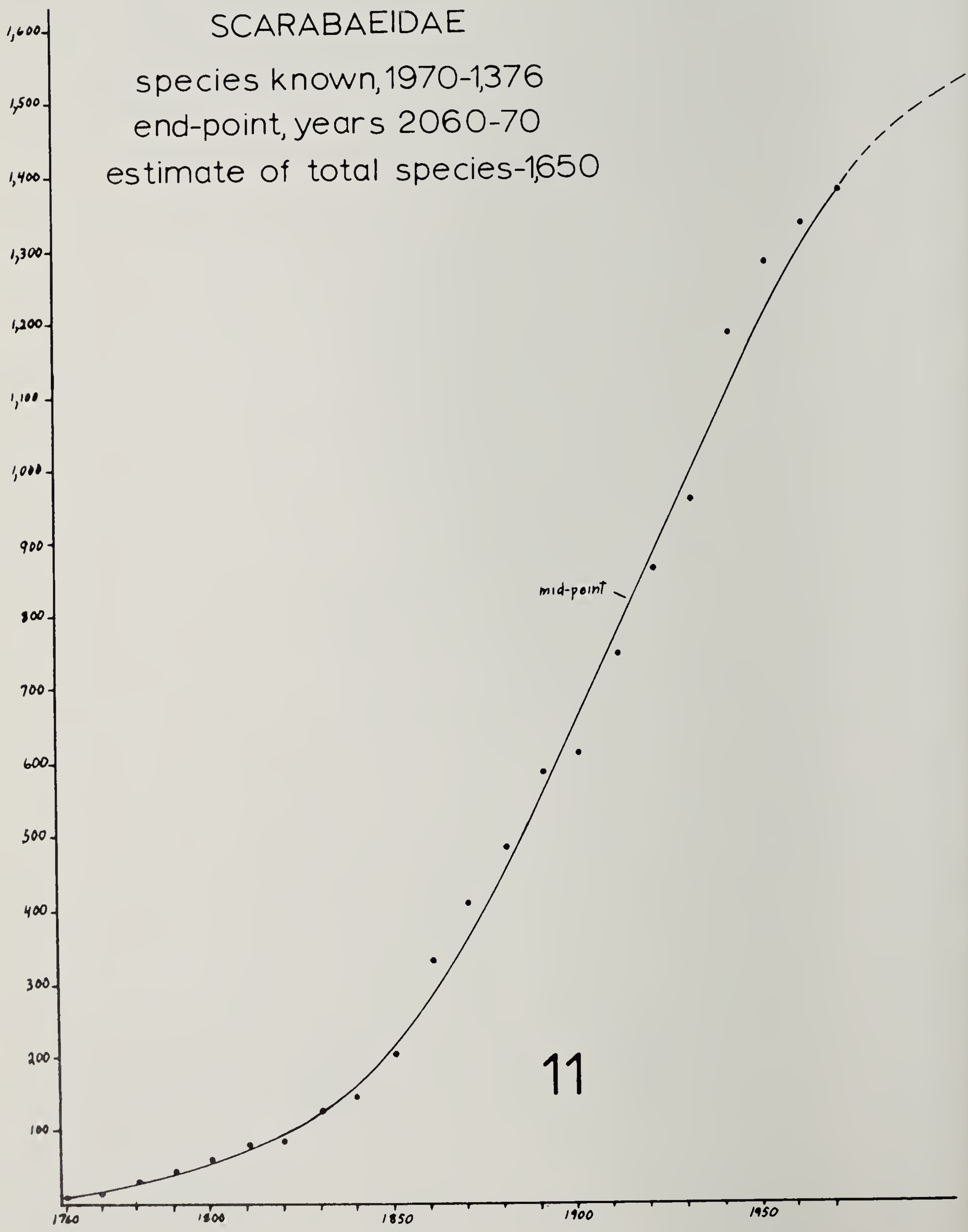


trasted to the prediction by theory of 920 species) and for the Scarabaeidae a final species total of 1,500 (as contrasted to the prediction by theory of 1,650 species). The new species totals for the next 2 or 3 decades should clarify the situation for each of these families and provide commentary on the predictive value of trend curve graphs for groups with characteristics similar to those of these 2 families.

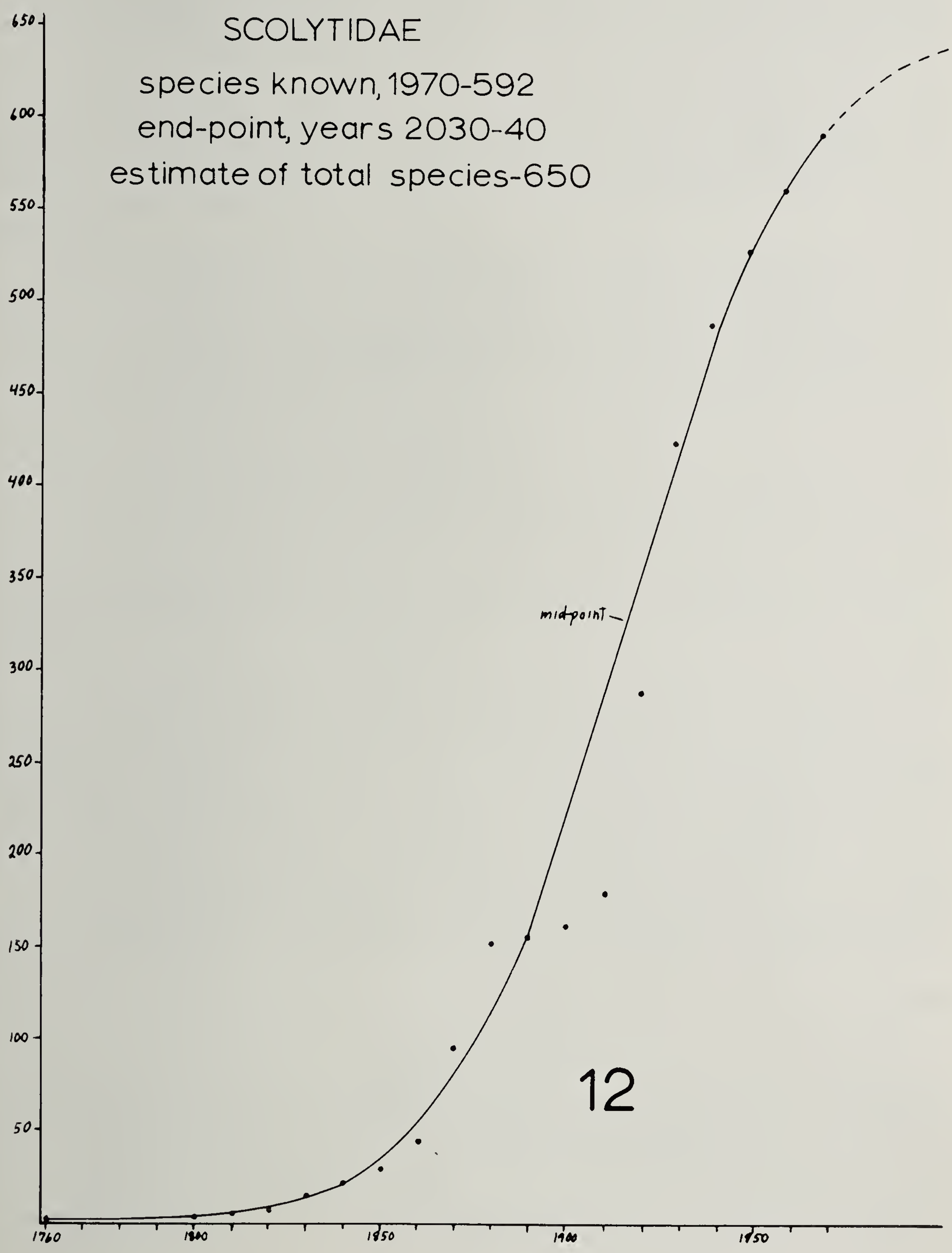
In drawing a curve I feel that interpretation of the significance of the trends on graphs is sometimes essential. If Fig. 10 (Melyridae) is examined,



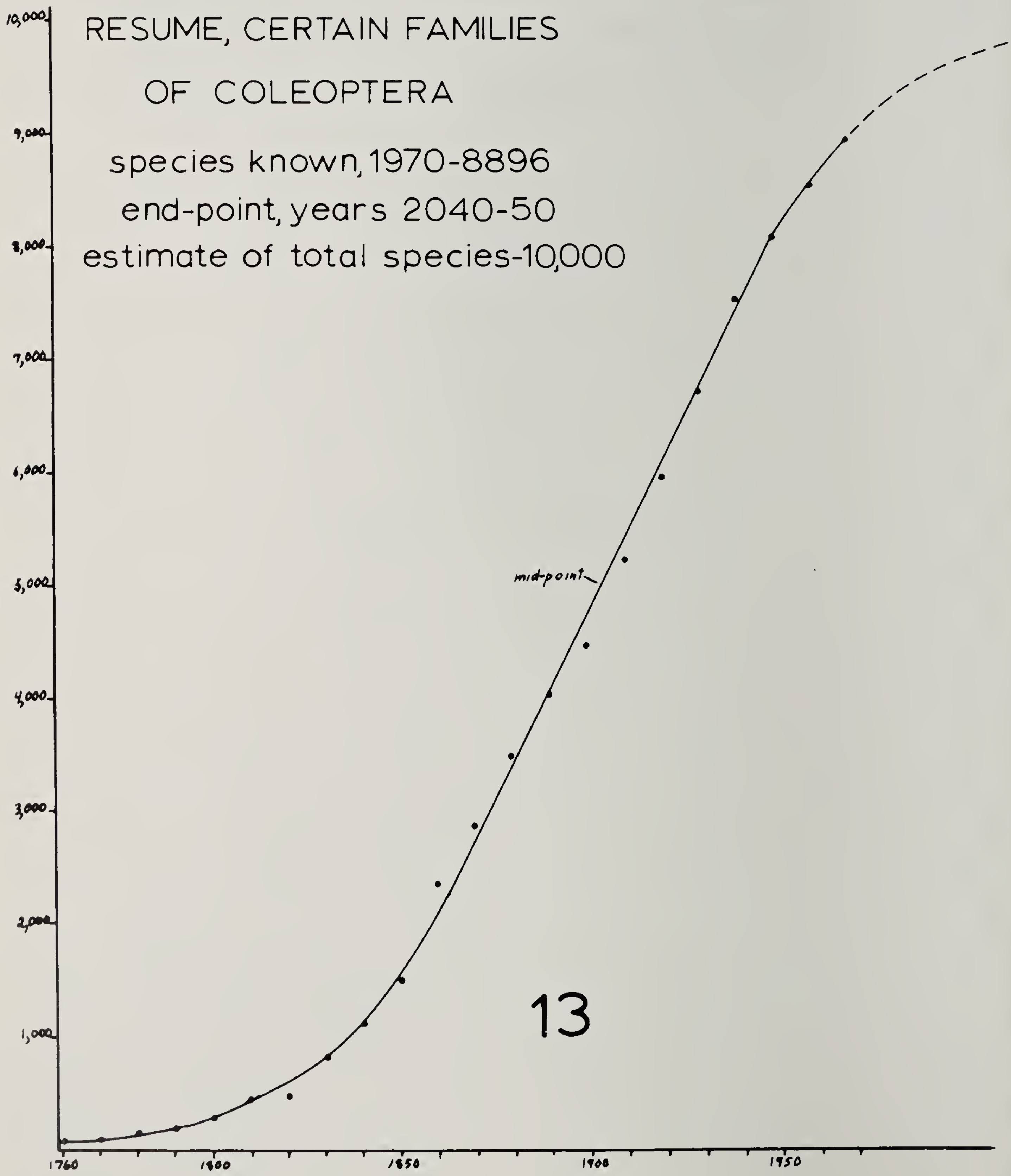
it will be seen that I have not connected the curve with the last point for 1970, but rather with that for 1960. I interpret the small number of additional new species for the period of 1960-70 (a total of 2) as representing lagging taxonomic progress and not an indication that the end-point of species description for the family is near. The nature of the history of species description in this family indicates that the family is susceptible to periods of slow progress in species description followed by accelerated rate of species description. Note that there are 4 decades in the early development of the curve in which no species were described, and note also the 3 periods of



slow growth in species number followed by great increase in this number. It is even possible that there could occur another decade of great increase in species number as occurred from 1850-60, 1890-1900, and 1920-30. If this should occur, my estimate could turn out to be too low. For the Dytiscidae (Fig. 6) I have again connected the curve to the next-to-last point rather than to the last, for I believe that the last point again represents lagging taxonomic progress. Elateridae (Fig. 7) are another family that exhibits irregular taxonomic progress, though this is less extreme than that shown for the Melyridae.



Extension of the curves I have made to the point where they level off gives the range of years for the approximate end-point of species description for most families of about 2,010 to 2,020. It can thus be expected that species description in most North American beetle families will be essentially completed at about that time with relatively few additional species described thereafter. These end-points for the families I have plotted on curves vary from 1970-80 for the Cicindelidae to 2,080-90 for the Buprestidae, and 2,090-2,100 for the Cantharidae, Lampyridae, and Lycidae (I have grouped these 3 families). The more advanced dates for the latter families of the anticipated end of species description might be an indication that these families contain many sibling species that will take considerable effort to discover. The final curve (Fig. 13) gives an end-point in the range of 2040-50. I in-



terpret this to mean that for those families I have plotted, 99% or more of the species of beetles in North America will by that time be known, with continued species description of any extent only in certain families in which taxonomic work has lagged, or in which collection of species is especially difficult because of small populations or cryptic habits, or in which many species are so similar that their separation requires considerable study.

A recent attempt to estimate the numbers of beetles in North America was made by Arnett (1967). By considering various factors, he estimated the final total of species for each family of beetles in North America, and from these figures arrived at a total for all North American beetles. In general there is a good agreement between his figures and those herein presented, but in the case of some families, differences between his figures and mine are considerable. The greatest discrepancy occurs in the Dytiscidae. Arnett gave 329 species to 1948; I have 453 species described to 1950, and 473 to 1970. The final species total for Dytiscidae estimated by Arnett is 350; mine is 488. Another large discrepancy occurs in the Elateridae; Arnett estimated the final total of 950 whereas my estimate is 810. In one instance our estimates agree exactly; both of us arrive at the figure of 350 total species for the Meloidae.

Arnett's estimate of the total number of species of beetles in North America to 1966 was 24,128. By accepting this figure and applying it to my graph of final species total (Fig. 13), I arrive at the figure of 88% of all species being known to 1966. The curve on my graph then gives the final total species in North America of about 27,400, as compared with Arnett's estimate of 28,600. My graph was compiled from a total of 8,896 species, about 36% of the total number of species of beetles known to 1970.

It must be recognized that, because of the nature of the taxonomic work of Thomas L. Casey, any tabulation of described species of beetles in North America unavoidably contains Casey names that will likely in the future be synonymized. Unfortunately, we cannot now know the exact extent of the undetected synonymy, so any species totals for the Coleoptera, including those given above, are possibly greater than the actual number in North America.

I have used the species totals of 29 families of beetles in compiling data for the final curve (Fig. 13). These families are as follows: Anobiidae, Anthribidae, Bostrichidae, Bruchidae, Buprestidae, Cantharidae, Chrysomelidae, Cicindelidae, Ciidae, Cleridae, Colydiidae, Dytiscidae, Elateridae, Erotylidae, Eucnemidae, Hydrophilidae, Lampyridae, Languriidae, Lycidae, Lyctidae, Meloidae, Melyridae, Mordellidae, Nitidulidae, Oedomeridae, Ptiliidae, Scarabaeidae, Scolytidae, and Trogositidae.

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